Optimal Carbon Policy under Carbon Inequality [*]

Tasnia Hussain [†]

September 27, 2025

Abstract

Rich households generate a disproportionate share of carbon emissions, particularly after accounting for their emissions from both consumption and investment. I develop a quantitative general-equilibrium model with heterogeneity in wealth and emissions from production and consumption to design carbon policy under a fixed abatement target. Three instruments deliver the same moderate abatement: (i) a tax on "basic" household energy usage, (ii) a shareholder-facing tax on production emissions, and (iii) a uniform tax on all emissions. The trade-offs are sharp. A production-emissions tax contracts output and wages yet raises welfare for all wealth groups and reduces carbon inequality. A basic-good tax boosts output but worsens carbon inequality and lowers welfare. A uniform tax balances these effects, with smaller welfare gains than a production tax. I then implement a tax on consumption of "luxury dirty goods" that only affects rich households. It delivers little abatement yet curbs carbon inequality. The optimal policy mix with different rates on production and consumption emissions yields better economic outcomes and higher welfare than a uniform carbon tax achieving the same level of abatement.

Keywords: Climate Change, Inequality, Taxation, Wealth

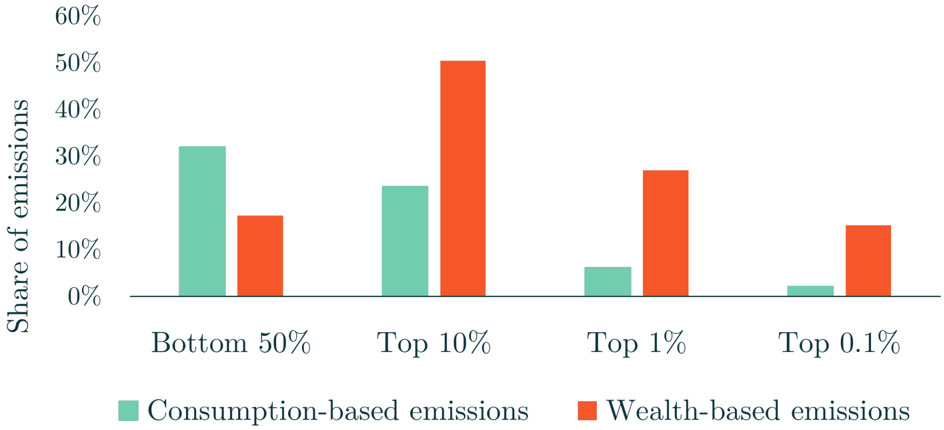
[*]I wholeheartedly thank my co-supervisors, Joseph B. Steinberg and Eduardo Souza Rodrigues, for their unwavering support and generous guidance throughout every stage of this paper. Additionally, I extend thanks to Gueorgui Kambourov for his invaluable feedback and suggestions which greatly enriched the quality of this paper. Special thanks to Jared Starr for graciously sharing data. Financial support from the Ontario Graduate Scholarship Program and the University of Toronto is gratefully acknowledged.

[†]University of Toronto Department of Economics. Contact: tasnia.hussain@mail.utoronto.ca

1 Introduction

The "polluter elite", wealthy individuals with polluting consumption habits and sources of income, contribute disproportionately to depleting the carbon budget limiting warming to 1.5°C (Chancel, 2022; Starr et al., 2023a,b). Wealth-based carbon footprints are far more unequal than consumption-based ones. While under consumption-based measures, the top 0.1% of wealth account for 2.2% of U.S. emissions, this share is 15.3% after including emissions generated by their asset ownership (Chancel and Rehm, 2023). Using a macroeconomic model generating realistic concentrations of U.S. wealth and carbon emissions, this paper studies how carbon taxation should be structured when emissions are extremely concentrated and can arise from production and consumption choices.

Figure 1: Distribution of emissions by wealth group in the U.S



Notes: This figure uses data from Table 3 of Chancel and Rehm (2023) reporting the emission shares of each net personal wealth group in the U.S. using both consumption-based and ownership-based approaches

This analysis departs from the standard question of how much abatement *should* occur, finding the social cost of carbon, and its path over time. Instead, conditional on an abatement target, I study the optimal structure of carbon policy and which economic activities it should directly target. I consider a shareholder-facing tax, referred to as a tax on production emissions, and a basic (necessity) dirty goods tax, levied on consumption emissions. I compare these alternative ways of achieving the abatement target on key economic outcomes and contrast them to the performance of a uniform carbon tax with the same abatement target in this heterogeneous setting. Furthermore, as my model can generate the polluter elite who consume polluting luxury goods, I evaluate the effects of a luxury dirty goods tax, a policy increasingly proposed to curb carbon inequality.

While the literature has extensively studied the optimal uniform carbon tax using a representative agent framework (Golosov et al., 2014; Nordhaus and Boyer, 2003), heterogeneity in consumption and production emissions can lead to a departure from a uniform carbon tax as the optimal tool. In a general equilibrium framework where an individual's carbon footprint arises from consumption *and* production choices, taxing consumption emissions induces different economic outcomes than taxing production emissions. The second reason to consider alternatives to a standard carbon tax is the political infeasibility. For the world's second largest polluter, implementing a carbon tax has repeatedly proven politically unattainable. The Clinton and Obama administrations both failed to implement carbon taxation. Clinton's "BTU" tax failed in 1994, as heavy industry convinced customers their power bills would surge. The public distaste for carbon pricing, due to perceptions that it is borne regressively by low-income households, can compromise public support for carbon policies, as was the case in France during the Yellow Vest protests (Douenne and Fabre, 2020). Lastly, the distinction between consumption- and production-based carbon pricing has contemporary policy implications, especially in designing a politically viable carbon policy. Canada, for example, used to have a consumer carbon price distinct from its industrial carbon pricing. While the consumer fuel charge was repealed in 2025 ahead of a tight election, the industry-facing carbon price remains. As countries explore various ways to structure their carbon policy, evaluating the economic impacts of consumer- and producer-facing carbon pricing is now increasingly relevant.

Building on the framework of Guvenen et al. (2023), I integrate an energy sector into a quantitative overlapping-generations model with rate-of-return heterogeneity. On the consumption side, households have non-homothetic preferences over the consumption of a basic dirty good, a luxury dirty good, and a non-energy good. While many papers feature heterogeneity in consumption emissions, this paper goes a step further by featuring heterogeneous emissions arising from production. Entrepreneurs, who operate a business and earn monopoly profits, also use energy to produce. With heterogeneous entrepreneurial ability and the ability to leverage their wealth, subject to a collateral constraint, the model delivers extreme wealth concentration and the carbon footprint of both wealth and consumption. This makes it the ideal laboratory to study the impacts of targeted policies.

The differentiated goods made by the entrepreneurs are then sold to the final good producer, employing labour to aggregate them and produce a final non-energy consumption good, sold back to the households. Individuals have heterogeneous labour productivity and face idiosyncratic productivity risks every period, supplying labour to either the final good or energy firm. After retirement, they receive social security payments from a government that runs a balanced budget by raising revenue using a variety of taxes.

Energy is produced using a linear technology employing labour, with energy demand coming from entrepreneurs and a portion sold directly to the households as they consume their basic and dirty goods. This energy generates emissions. I abstract from a climate feedback loop that maps emissions back to output damages since abatement is held fixed across policies, leaving climate damages identical for each experiment. This approach allows me to sidestep the contentious question of which damage estimate to use, a debate that remains highly uncertain and varies by orders of magnitude in the literature.

Section 5 contains the experiments reducing emissions by 10% using three instruments; the basic dirty good tax, τ_{d_1}; the production emissions tax, τ_s, and lastly, the uniform carbon tax τ_e which taxes production and consumption emissions equally. The welfare analysis for each experiment is done using consumption equivalents of the non-energy good. A conservative estimate of the social cost of carbon (SCC) is used to quantify the social benefits of reducing U.S. emissions by 10%, keeping this analysis separate from the welfare arising from the economic impacts of various tax policies. To make these two analyses comparable, I scale the consumption equivalents by U.S. private financial consumption expenditure in 2019 for the non-energy expenditure share of the household's consumption basket and then express it relative to U.S. 2019 GDP. I then also express the social value of emission reductions relative to U.S. 2019 GDP.

Beginning with the production emissions tax, targeting entrepreneurial activity directly by taxing entrepreneurs' energy use, while successfully decreasing the top 0.1% of wealth's share of emissions, reduces output and wages. Despite output declining, misallocation improves as TFP rises slightly, due to differential responses from constrained and unconstrained entrepreneurs. When this policy increases energy prices, unconstrained firms reduce energy usage uniformly and scale back on capital. In contrast, constrained entrepreneurs, who are typically more productive, face capital constraints and reduce energy usage more sharply. Hence capital concentrates among highly productive firms, improving TFP and increasing wealth concentration. Overall, emissions from entrepreneurial activity among wealthy households decline, reducing carbon inequality. This heterogeneous adjustment highlights the importance of producer-facing instruments, which disproportionately target emissions at the top while improving aggregate efficiency.

Despite wages falling, this policy improves welfare across the wealth distribution, because while low-wealth groups benefit from the transfer, even wealthy households make welfare gains due to the non-homothetic preferences. While the production-emissions tax makes the non-energy good more expensive, richer households switch to the relatively cheaper untaxed dirty goods, especially the luxury good. This rise in consumption emissions does not undo the production emissions abatement, allowing the economy to achieve its abatement goal while simultaneously benefiting all wealth groups.

In contrast, the basic dirty good tax increases output the most of all policies and delivers the lowest wage decline. Taxing the household's basic dirty good consumption induces a substitution towards the untaxed non-energy good, produced using the entrepreneurs' products. This increased demand results in entrepreneurs expanding their activity, demanding more energy and capital to operate. Capital allocation improves, as the reduced incentive to consume relaxes the capital constraints of constrained households who accumulate more wealth, allowing them to produce more. This expansion in output worsens carbon inequality as entrepreneurial energy usage rises. Additionally, newborns and the population experience welfare losses, despite households receiving a large rebate. While these transfers benefit the least wealthy households, who consume more of the non-energy good, consumption of the necessity dirty good declines across the board. Lowest wealth households experience a small welfare gain but all other groups experience welfare losses, explaining the political economy of why consumption-emission taxes are often unpopular even with rebates. Although richer households substitute towards the luxury dirty good, it cannot compensate for the reduction in their basic dirty good consumption, resulting in even the rich suffering under this policy. This is in stark contrast to the production emissions tax, where they also see welfare gains. In summary, this instrument delivers higher output and lower welfare, a mirror image of production-side taxation.

Next, I use a uniform carbon tax targeting all types of emissions equally to reach 10% abatement. First, output rises slightly because of the labour reallocation and TFP channel. The raw inputs channel drags output down, but less so than the shareholder tax since the transfers and consumption-emissions side of the uniform tax induces households to demand more of the non-energy consumption good produced by entrepreneurs. Additionally, for some households, the reduced incentive to consume across all the goods encourages savings, relaxing collateral constraints for constrained entrepreneurs, so entrepreneurial activity increases for these groups. These mechanisms buffer the decline in output otherwise occurring when taxing production emissions. Nevertheless, entrepreneurial activity declines and with it, the carbon shares of the wealthiest, but by less than the production emissions tax. While the economic contraction also reduces wages, low-wealth groups experience welfare gains due to the transfer, but all other wealth groups face welfare losses since their consumption across all goods declines. Consequently, newborn welfare declines, while average population welfare increases marginally, made possible by the welfare gains of the lowest-wealth groups. However, this gain is less than the one delivered by the production emissions tax. So while output does increase under this policy, for newborn welfare we see the same output-welfare trade-off as under the consumption emissions tax. The population welfare gain is largely due to the transfers benefiting low wealth groups, whereas under the shareholder tax, all wealth groups experienced welfare gains.

Lastly, I set a sufficiently high tax on luxury dirty goods to eliminate their use. Emissions decline by 0.4% and while wealthy households substitute to the basic dirty and non-energy good, this does not offset their luxury dirty good abatement. However, output rises slightly due to the increased demand for the non-energy good and entrepreneurs slightly expand their activity. Despite this, rich households experience welfare losses from eliminating their luxury consumption, resulting in overall welfare losses. These welfare losses are still dwarfed by the social value of the emissions reduction.

Section 6 evaluates the robustness of my findings to different abatement targets. First, the basic dirty good tax alone can only abate up to 15%, with steep welfare losses relative to the other instruments, reflecting the painful nature of taxing a necessity. In contrast, the shareholder tax as a standalone instrument is welfare-improving until roughly 21% and 28% for newborns and the overall population respectively. After this, welfare turns negative but still outperforms the uniform carbon tax. This reverses at 40% abatement, over which the uniform tax is better for most wealth groups than relying on any single instrument alone. This is because the shareholder tax reduces output more steeply, and while low-wealth and extremely wealthy households still like this policy, everyone else in between suffers from the lower wages and contracted entrepreneurial activity.

Overall, the abatement experiments show that no single instrument dominates when evaluated across multiple dimensions, such as output, wages, welfare, carbon inequality, and distributional equity, while also meeting the abatement constraints at moderate levels of abatement. This provides the rationale for an optimal policy structure using a mixture of targeted policies. In Section 7, this paper explores optimal policy structures. The U.S. has pledged to reduce emissions to 50% of 2005 levels, and as of 2022, they are at 17%. The optimal policy finds the most welfare-maximizing mix of producer-facing and consumer-facing emissions taxes to achieve the remaining 34% reduction, and compares it to the welfare and economic outcomes of solely relying on a uniform carbon tax to achieve the same abatement. The optimal policy relies on taxing emissions from luxury and basic dirty good consumption relatively higher than production emissions. This differential treatment results in smaller newborn welfare losses (-0.2% as opposed to -1%) and a reversal of population welfare loss to a gain (from -0.7% to +0.12%). This softer landing comes at the cost of a smaller reduction in the top 0.1% share of emissions compared to the uniform tax (-9.6% vs. -10.7%). Nevertheless, these improvements arise because the optimal policy leverages the tools that buffer a decline in entrepreneurial activity. The heavier taxes on consumption emissions induce households to substitute away from dirty goods to the non-energy good produced by the entrepreneur, while also encouraging more saving. The relatively lower taxes on production emissions allow entrepreneurs to adjust their operations, softening the contraction otherwise occurring with the uniform tax.

Related Literature

This paper contributes to three strands of literature. The first strand investigates the carbon footprints of the rich, studying how carbon inequality differs when emissions are measured through consumption, income, or wealth (Starr et al., 2023a,b). These differences intensify most when moving from consumption- to wealth-based measures (Chancel, 2024). I use these empirical insights to calibrate my model and extend the literature by providing the first quantitative general equilibrium framework capturing carbon inequality arising heterogeneously from consumption and production. The growing concern over carbon inequality has led to calls for policies targeting high emitters, such as a shareholder-based emissions tax, policies that this paper can evaluate in general equilibrium.

The second strand of literature embeds heterogeneous agents and incomplete markets into the standard climate-economy models of Golosov et al. (2014); Nordhaus and Boyer (2003) to investigate the distributional impacts of climate policy and deliver optimal second-best climate policies in an environment with heterogeneity. Douenne et al. (2023), introduce heterogeneity in labour market productivity and initial wealth holdings, generating a top 1% wealth share with superstar productivity shocks. With Stone-Geary preferences over a basic dirty good, income heterogeneity leads to households with varying consumption carbon footprints and delivers a lower optimal carbon tax than in a representative agent setting. Belfiori et al. (2024) similarly have non-homothetic preferences but find that the optimal carbon tax in a heterogeneous set-up should also be heterogeneous and higher for higher-income households. The contribution of my paper lies in incorporating rate of return heterogeneity, a dimension allowing the model to capture wealth-based carbon footprints and provides a framework to study how production heterogeneity shapes the emissions distribution. Entrepreneurship provides additional mechanisms through which capital ownership can impact how carbon taxes affect aggregate variables such as output, emissions, and wages. Moreover, my paper also introduces non-homothetic preferences over luxury dirty goods, allowing for the possibility of non-monotonic Engel curves in carbon consumption, as documented by Starr et al. (2023a). With the extreme wealth concentration it delivers, the model generates the individuals who indulge in the super-polluting luxury consumption that is at the center of media attention. These extensions allow for a nuanced analysis of the role of targeted taxes.

The third strand of literature investigates how carbon policies interact with firm heterogeneity and impact misallocation. Lyubich et al. (2018) document heterogeneity in energy productivity, defined as output per dollar of energy input across U.S. manufacturing plants. Caggese et al. (2024) use a general equilibrium structural model and find that climate change induces factor reallocation, particularly of labour and not capital, potentially reducing allocative efficiency. Kim (2023) uses a quantitative firm dynamics model and finds a higher optimal carbon tax when emissions intensity and marginal products of production factors are negatively correlated, as a carbon tax improves allocative efficiency in the presence of financial frictions and adjustment costs. My paper moves beyond a firm-based approach to a firm-owner approach, capturing the rich individuals who control and benefit most from operating highly polluting firms. This has implications for wealth and carbon inequality, a dynamic obscured when solely using a firm-based approach.

2 Model

I consider an overlapping generations model in which households make intertemporal decisions over consumption and savings. Some households also act as entrepreneurs and operate a business directly. Entrepreneurs choose capital and energy inputs, subject to a collateral constraint. Emissions arise from both household consumption of dirty goods and the energy used in production. These sources of emissions can be taxed separately or together, with taxes being rebated back to households. I now present each component of the model in detail, beginning with households, then firms, and lastly, the government.

2.1 Households

In this overlapping generations framework, agents make consumption and saving decisions each period. Agents face uncertainty around their mortality every period, with the conditional probability s_h of living from age $h-1$ to h. The unconditional probability of surviving until age h is ϕ_h. Mortality risk increases as they age, with the maximum possible age being H years. If an agent dies, their child inherits all their wealth in the form of an accidental bequest.

The household's discounted expected lifetime utility is defined as follows:

$$\mathbb{E}_0\left[\sum_{h=1}^{H} \beta^{h-1} \phi_h \, u(c_h, d_{1h}, d_{2h})\right] \tag{1}$$

The household derives utility $u(\cdot)$ from consuming the following three goods: the final non-energy good c_h, direct consumption of a basic energy good d_{1h} that is dirty for necessities such as heating homes, and direct consumption of a luxury energy good d_{2h} that is only consumed by ultra-wealthy individuals, such as the usage of a super yachts, private jets, and multiple large residences that need heating and cooling. They have non-homothetic preferences over the basic and luxury dirty good. Lastly, β is the standard discount factor.

During their working life, they supply labour inelastically. After they hit the mandatory retirement age R, they draw on social security payments. In addition to labour income, they can also operate an entrepreneurial endeavour at all periods, conditional on having such an opportunity. I describe the labour market and entrepreneurship process next.

2.2 Labour Market

The labour market productivity process is modelled as in Rotberg and Steinberg (2024) :

$$\log \theta_h(\kappa_i) = g(h) + \kappa_{ih} \tag{2}$$

where an individual i's labour market productivity consists of a component that varies with age h and an idiosyncratic shock they receive during their working years, after which it stays constant. The shock evolves as follows during their career:

$$\kappa_{ih} = \rho_\kappa \kappa_{i,h-1} + \epsilon_{ih} \text{ where } \epsilon_{ih} \sim N\left(0, \sigma_\kappa^2\right) \ , |\rho_\kappa| < 1 \tag{3}$$

At death, this shock is then imperfectly passed onto their offspring:

$$\kappa_{i0}^{child} = \bar{\rho}_\kappa \kappa_{iR}^{parent} + v_i \text{ where } v_i \sim N\left(0, \bar{\sigma}_\kappa^2\right) \ , |\bar{\rho}_\kappa| < 1 \tag{4}$$

All labour is then supplied inelastically, leading to the following aggregated effective labour supply:

$$L = \int \theta_{ih} didh \tag{5}$$

2.3 Entrepreneurship

Agents operate their businesses to produce an intermediate differentiated good x_{ih} using their entrepreneurial ability z_{ih}, which is a function of both their permanent underlying ability and idiosyncratic shocks they receive every period. They inherit the permanent component from their parents at birth according to the following process:

$$\log\left(\bar{z}_i^{child}\right) = \rho_{\bar{z}} \log\left(\bar{z}_i^{parent}\right) + \epsilon_{\bar{z}_i} \text{ where } \epsilon_{\bar{z}_i} \sim N\left(0, \sigma_{\bar{z}}^2\right) \ , |\rho_{\bar{z}}| < 1 \tag{6}$$

This imperfect transmission is a source of capital misallocation in Guvenen et al. (2023) as fortunes may be amassed by the undeserving (i.e., children who are less talented than their parents) while children with high innate entrepreneurial abilities relative to their parents may inherit too little.

Let $\omega_{ih} \in \{\mathcal{H}, \mathcal{L}, 0\}$ be a state variable that denotes agent i's entrepreneurial state at age h. The stochastic component described below captures the positive or negative shocks to their baseline inherited ability that an entrepreneur may experience over the course of their life. They can either receive a positive shock and be in state $\omega_{ih} = \mathcal{H}$, which boosts their underlying ability, denoted by ${\bar{z}_i}^\lambda$. That boost, however, could dissipate the following year, leaving them with just their baseline ability $\bar{z}_i$ if $\omega_{ih} = \mathcal{L}$. It could also disappear entirely with $z_{ih} = 0$ when $\omega_{ih} = 0$, forcing them to leave the business. This stochastic variation will be key in generating some features of wealth inequality.

$$z_{ih} = \begin{cases} \bar{z}_i^{\lambda}, & \text{if } \omega_{ih} = \mathcal{H}, \\ \bar{z}_i, & \text{if } \omega_{ih} = \mathcal{L}, \\ 0, & \text{if } \omega_{ih} = 0. \end{cases} \tag{7}$$

with transition matrix (rows/columns ordered as $(\mathcal{H}, \mathcal{L}, 0)$):

$$\Pi_{\omega} = \begin{pmatrix} 1 - p_1 - p_2 & p_1 & p_2 \\ 0 & 1 - p_2 & p_2 \\ 0 & 0 & 1 \end{pmatrix} \tag{8}$$

2.4 The Entrepreneur's Decision

The entrepreneur i at age h operates a Cobb-Douglas production technology that combines their entrepreneurial abilities z_{ih} with capital and energy to produce a differentiated good x_{ih}. The simultaneous use of capital and energy implies that emissions reduction can come from the substitution of capital over energy, which can be interpreted as energy-efficiency improvements since capital does not have a carbon footprint in this model.

$$x_{ih} = z_{ih} {k_{ih}}^{\gamma_k} e_{ih}^{\gamma_e} \tag{9}$$

Using this technology, they solve the following static problem at each age h in which they maximize profit by choosing the level of capital, subject to a collateral constraint, for which they go to a financial market and engage in collateralized borrowing that depends on their asset position a, at a risk free rate r. Importantly, $\vartheta(\bar{z})$ is structured to capture that higher productivity entrepreneurs can leverage more than their less productive counterparts, controlling for wealth. This specification is grounded in literature documenting earnings and cash-flow based borrowing (Li, 2022; Lian and Ma, 2020). Next, entrepreneurs also choose the level of energy to employ, where this energy usage is subject to a shareholder-facing tax on production emissions τ_s:

$$\pi_h(a, z) = \underset{k \leq \vartheta(\bar{z})a, e}{max} \; p\left(z k^{\gamma_k} e^{\gamma_e}\right) \times \left(z k^{\gamma_k} e^{\gamma_e}\right) - (r + \delta) k_h - p_e (1 + \tau_s) e_h \tag{10}$$

where $p\left(z k^{\gamma_k} e^{\gamma_e}\right)$ comes from solving the final good producer's problem so that:

$$p(x) = \mathcal{R} \times (x)^{\mu-1} \tag{11}$$

where:

$$\mathcal{R} \equiv \alpha Q^{\alpha-\mu} L_y^{1-\alpha} \tag{12}$$

The firm's policy functions for capital and energy demanded are:

$$k_h(a,z) = \min\left\{ \left[\mathcal{R}\,\mu\, z^{\mu} \left(\frac{r+\delta}{\gamma_k}\right)^{\mu(1-\gamma_k)-1} \left(\frac{p_e(1+\tau_s)}{1-\gamma_k}\right)^{-\mu(1-\gamma_k)} \right]^{\frac{1}{1-\mu}} ,\ \vartheta(\bar{z})\ a \right\} \tag{13}$$

$$e_h(a,z) = \left[\frac{p_e(1+\tau_s)}{\mathcal{R}\,\mu\ (1-\gamma_k)\ z^{\mu}\, k_h(a,z)^{\mu\gamma_k}} \right]^{\frac{1}{\mu(1-\gamma_k)-1}} \tag{14}$$

2.5 Final Good Producer

The final good Y is an aggregation of the intermediate goods produced by the entrepreneurs and combined using labour supplied by households L_y. It is produced using the following Cobb-Douglas technology:

$$Y = Q^{\alpha} L_y^{1-\alpha} \tag{15}$$

where Q is the quality-adjusted capital-energy composite as firms will produce x_{ih} with both capital and energy. α is the share of production accounted for by the capital-energy composite:

$$Q = \left(\iint x_{ih}^{\mu}\, di\, dh \right)^{1/\mu} \tag{16}$$

Total factor productivity in the Q sector is then defined as:

$$\text{TFP}_Q \equiv \frac{Q}{\int k_i^{\gamma_k} e_i^{\gamma_e}\, di} \tag{17}$$

where the denominator contains the combination of raw inputs used by all the entrepreneurs, but unadjusted for quality.

The final good firm's maximization problem is then:

$$\max_{\{x_{ih}\},\,L_y} \ \left(\iint x_{ih}^{\mu}\, di\, dh\right)^{\alpha/\mu} L_y^{1-\alpha} \ - \ \iint p_{ih}\, x_{ih}\, di\, dh \ - \ wL_y \tag{18}$$

where w is the wage per efficient unit of labour.

2.6 Taxes and Transfers

The model has six taxes; a tax on capital income τ_k, τ_ℓ for labour income, τ_{d_1} for the basic dirty good emissions, τ_{d_2} for the luxury dirty good emissions, τ_e on the energy firm, and τ_s for the energy used by entrepreneurs. The capital income tax applies post-production. The government uses tax revenues to finance social security payments and public goods, G, but the latter do not enter anywhere in the household's problem. While in the benchmark equilibrium there are no lump-sum transfers, any additional revenue generated by the experiments will be rebated to households as lump-sum payments.

2.7 Household's Problem

The household chooses how much of the non-energy (c) and energy (d_1, d_2) goods to consume, as well as their savings for the next period. After production, the household's total wealth at the end of the period includes their starting wealth, their entrepreneurial profits, and lastly, their returns on accumulated wealth, subject to a risk-free interest rate of r:

$$\mathcal{Y}_h\left(a,z\right) = a + \Big[\pi_h\left(a,z\right) + ra\Big]\left(1-\tau_k\right) \tag{19}$$

Let

$$\mathbf{S} \equiv \left(a, \kappa, \bar{z}, \omega\right) \tag{20}$$

denote the vector of exogenous individual states, where κ is labour efficiency, $\bar{z}$ is baseline entrepreneurial ability, $\omega \in \{\mathcal{H}, \mathcal{L}, 0\}$ shocks the baseline entrepreneurial state, and a the household's asset levels upon entering the period. Then the household's dynamic problem is the following:

$$V_h\left(\mathbf{S}\right) = \underset{c,a',d_1,d_2}{max} \ \Big\{u\left(c,d_1,d_2\right) + \beta s_{h+1}\mathbb{E}_h\Big[V_{h+1}\left(\mathbf{S}'\right)\Big]\Big\} \tag{21}$$

subject to $c \geq 0, d_1 \geq \bar{d_1}, d_2 \geq -\bar{d_2}, a' \geq 0$ and:

$$c + (1 + \tau_{d_1})\, p_e\, d_1 + \frac{(1 + \tau_{d_2})\, p_e}{A_2}\, d_2 + a' = \mathcal{Y}_h\,(a, z) + (1 - \tau_\ell)\, w\, \theta_h(\kappa) + T \tag{22}$$

where τ_{d_i} is an excise tax on the dirty goods and T is a lump-sum transfer

The two dirty goods will be produced using a linear technology where energy is the only input. The luxury good will use $\frac{1}{A_2}$ times more energy.

The retiree's problem is the same except they no longer receive wage income and instead rely on social security payments.

2.8 Energy Sector

Energy production is modelled to resemble stylized features of only coal extraction for simplicity, using a technology linear in labour:

$$e = A_e L_e \tag{23}$$

Energy firms face a carbon tax τ_e on their production, with the following maximization problem:

$$\begin{aligned} &\max_{L_e}\ (1 - \tau_e)\ p_e\, e - wL_e \\ &\text{s.t. } e = A_e L_e \end{aligned} \tag{24}$$

Energy produced in the energy sector is used by all the intermediate good firms or directly consumed by households in the form of the basic d_1 or luxury good d_2. The energy market clearing condition is:

$$e = \int e_i\, di + \int d_{1i}\, di + \frac{1}{A_2} \int d_{2i}\, di \tag{25}$$

2.9 Recursive Competitive Equilibrium

Definition 1 (Recursive Competitive Equilibrium) *Let the individual state be* $\mathbf{S} = (a, \kappa, \bar{z}, \omega)$*. Given a stationary distribution* $\Gamma_h\,(\mathbf{S})$ *of individuals over the state variables* $\mathbf{S}$ *and taxes* $\{\tau_k, \tau_\ell, \tau_e, \tau_{d_1}, \tau_{d_2}, \tau_s\}$*, the recursive competitive equilibrium consists of the policy functions* $c_h\,(\mathbf{S})$*,* $d_{1h}\,(\mathbf{S})$*,* $d_{2h}\,(\mathbf{S})$*,* $a_{h+1}\,(\mathbf{S})$*,* $k_h\,(a, z)$*,* $e_h\,(a, z)$ *and prices* $\{p(x),\ w,\ r,\ p_e\}$*, which satisfy the following:*

(i) The decision rules solve the household's static and dynamic optimization problems given the prices and taxes.

(ii) The final good producer's solution yields $p(x)$*.*

(iii) Intermediate goods, bond, and energy markets clear:

$$Q = \left\{ \sum_{h=1}^{H} \int_{\mathbf{S}} \left[\left(z\, k_h\,(a,z)^{\gamma_k}\ e_h\,(a,z)^{\gamma_e} \right]^{\mu} d\Gamma_h(\mathbf{S}) \right\}^{1/\mu} \tag{11}$$

$$\sum_{h=1}^{H} \int_{\mathbf{S}} k_h\,(a,z)\ d\Gamma_h(\mathbf{S}) = \sum_{h=1}^{H} \int_{\mathbf{S}} a\, d\Gamma_h(\mathbf{S}) \tag{12}$$

$$\begin{aligned} e \ = & \sum_{h=1}^{H} \int_{\mathbf{S}} e_h\,(a,z)\ d\Gamma_h(\mathbf{S}) + \sum_{h=1}^{H} \int_{\mathbf{S}} d_{1h}(\mathbf{S})\, d\Gamma_h(\mathbf{S}) \\ & + \frac{1}{A_2} \sum_{h=1}^{H} \int_{\mathbf{S}} d_{2h}(\mathbf{S})\, d\Gamma_h(\mathbf{S}) \end{aligned} \tag{13}$$

(iv) The labour market clearing condition delivers w*:*

$$L_e + L_y = \sum_{h=1}^{R-1} \int_{\mathbf{S}} \theta_h(\kappa)\ d\Gamma_h(\mathbf{S}) \tag{26}$$

(v) The government budget constraint is satisfied:

$$\begin{aligned} G + T + \mathrm{SSP} \ = & \ \tau_k \sum_{h=1}^{H} \int_{\mathbf{S}} \left[ra + \pi_h\,(a,z) \right] d\Gamma_h(\mathbf{S}) \ + \ \tau_s\, p_e \sum_{h=1}^{H} \int_{\mathbf{S}} e_h\,(a,z)\ d\Gamma_h(\mathbf{S}) \\ & + \ \tau_\ell \sum_{h=1}^{R-1} \int_{\mathbf{S}} w\, \theta_h(\kappa)\, d\Gamma_h(\mathbf{S}) \ + \ \tau_e\, p_e\, e \\ & + \ \tau_{d_1}\, p_e \sum_{h=1}^{H} \int_{\mathbf{S}} d_{1h}(\mathbf{S})\, d\Gamma_h(\mathbf{S}) \ + \ \frac{\tau_{d_2}\, p_e}{A_2} \sum_{h=1}^{H} \int_{\mathbf{S}} d_{2h}(\mathbf{S})\, d\Gamma_h(\mathbf{S})\,. \end{aligned} \tag{27}$$

where SSP is the total pension payout:

$$\mathrm{SSP} = \sum_{h=R}^{H} \int_{\mathbf{S}} y^R(\kappa_{R-1})\ d\Gamma_h(\mathbf{S})\,. \tag{28}$$

(vi) For any measurable set A *in the state space and all* $h = 1, \ldots, H-1$*, the following law of motion governs the distribution of households:*

$$\Gamma_{h+1}(A) = s_{h+1} \int_{\mathbf{S}} \left\{ \sum_{\omega'} \sum_{\kappa'} \mathbf{1}_A \Big[a_{h+1}(\mathbf{S}),\, \kappa',\, \bar{z},\, \omega' \Big] \;\Pr(\kappa' \mid \kappa)\; \Pr(\omega' \mid \omega) \right\} d\Gamma_h(\mathbf{S}) \tag{29}$$

where $a_{h+1}(\mathbf{S})$ is the savings policy and $\bar{z}$ is fixed within life.

The age-1 cross-section of newborns is given by:

$$\Gamma_1(A) = \sum_{h=1}^{H} (1 - s_{h+1}) \int_{\mathbf{S}} \left\{ \sum_{\kappa_0} \sum_{\bar{z}_0} \mathbf{1}_A \Big[a_{h+1}(\mathbf{S}),\, \kappa_0,\, \bar{z}_0,\, \omega_{\mathcal{H}} \Big] \;\Pr(\kappa_0 \mid \kappa)\; \Pr(\bar{z}_0 \mid \bar{z}) \right\} d\Gamma_h(\mathbf{S})$$

3 Calibration

In order to replicate U.S. wealth and carbon inequality, I calibrate my model using both preset and internally calibrated parameters.

3.1 Preset Parameters

Table 1, Panel A summarizes all the preset parameters. These parameters are not used to match moments from the model to data moments. They are taken straight from the data or from values used in the literature.

Demographics

The maximum age and retirement age values are taken from Guvenen et al. (2023), with a maximum age $H = 81$ and retirement age of $R = 45$. I also follow them in taking conditional mortality risks from Bell and Miller (2005).

Final Good Production Parameters

The term α denotes capital and energy's share of output, which is taken from Golosov et al. (2014) to be 34%.

Labour Productivity

I use the Tauchen method to construct a grid for the labour productivity shocks which has 5 values. From Rotberg and Steinberg (2024), during their working period, the AR(1) process governing labour productivity has a persistence parameter of $\rho_\kappa = 0.937$

Table 1: Model Parameters

Parameter		Method / Source	Value	
Panel A: Preset Parameters				
Capital income tax	τ_k	McDaniel (2007)	23.65%	
Labour income tax	τ_ℓ	McDaniel (2007))	18.88%	
Intragenerational corr. of labour FE	ρ_κ	Guvenen et al. (2023)	0.937	
Std. dev. of the above	σ_κ	Guvenen et al. (2023)	0.201	
Intergenerational corr. of labour FE	$\bar{\rho}_\kappa$	Guvenen et al. (2023)	0.568	
Std. dev. of above	$\bar{\sigma}_\kappa$	Guvenen et al. (2023)	0.184	
Intergenerational corr. of entr. ability	$\rho_{\bar{z}}$	Guvenen et al. (2023)	0.10	
Capital–energy share	α	Golosov et al. (2014)	0.34	
CES substitution parameter	μ	Standard	0.90	
Luxury good energy intensity	A_2	Normalization	1	
Entrepreneur productivity boost	λ	Guvenen et al. (2023)	1.5	
Prob. high $\rightarrow$ low ability	p_1	Guvenen et al. (2023)	0.05	
Prob. losing ability	p_2	Guvenen et al. (2023)	0.03	
Depreciation rate	δ	Standard	0.05	
Panel B: Internally Calibrated Parameters			Data	Model
Discount factor	β	Target K/Y ratio	3.0	2.7
Std. dev. of permanent entr. ability	$\sigma_{\epsilon_{\bar{z}}}$	Target top 0.1% wealth share (Smith et al., 2022)	15.7%	15.5%
Luxury good parameter	$\bar{d}_2$	Target: only top 0.1% consume		
Subsistence level of d_1	$\bar{d}_1$	Target bottom 50% emissions share (Chancel and Rehm, 2023)	17%	17%
Rel. preference for d_1	ϵ_1	Target energy expenditure share (Starr et al., 2023a)	1.6	1.7
Rel. preference for c	ϵ_2	Target IG emissions share (Chancel and Rehm, 2023)	70%	70%
Energy share in IG production	γ_e	Target top 0.1% emissions (Chancel and Rehm, 2023)	15.3%	15.6%
Energy firm productivity	A_e	Target energy share of output	4%	4%

and $\sigma_\kappa = 0.201$, with the intergenerational parameters as $\bar{\rho}_\kappa = 0.568$ and $\bar{\sigma}_\kappa = 0.184$. The life cycle component function is taken from Guvenen et al. (2023) to be $g(h) = exp\left(\frac{-(h-1)^2}{1800} - \frac{(h-1)}{30}\right)$, which yields a hump-shaped productivity process which increases during the prime working years, reaches a peak, and then decreases as the individual ages.

Entrepreneurial Productivity Process

While the entrepreneurship process is internally calibrated and will be described in the next section, the grid for the entrepreneurial shocks is constructed using the Tauchen method with 9 grid values. The rest of the parameters governing the entrepreneurship process are taken from Guvenen et al. (2023). The productivity boost when receiving a positive shock, λ, is 1.5; the probabilities of losing the positive shock p_1 and the entrepreneurial abilities completely p_2 are 5% and 3%, respectively. Lastly, the intergenerational correlation of entrepreneurial ability is set to be 0.1.

Collateral Constraints

The functional form for the collateral constraint is defined to be $\vartheta\left(\bar{z}_\iota\right) = 1 + 0.025\left(\iota - 1\right)$ for $\iota = 1, \ldots, 9$, where ι denotes the index in the discretized grid constructed above for the entrepreneurship process. This follows the specification in Guvenen et al. (2023) and ensures that the lowest entrepreneurial productivity group cannot borrow and the ability to borrow increases with entrepreneurial ability.

Taxation

I use the average tax rates for labour and capital income generated using the method in McDaniel (2007), with a capital income tax of 23.65% and labour income tax of 18.88%.

3.2 Internally Calibrated Parameters

This set of parameters is determined jointly in the model. Table 1, Panel B contains the moments that are calibrated so that the model generates moments that match the data.

Preferences

Preferences are non-homothetic to capture that expenditure shares will be different across households:

$$u\left(c, d_1, d_2\right) = \epsilon_1 \ln\left(d_1 - \bar{d_1}\right) + \epsilon_2 \ln\left(c\right) + \left(1 - \epsilon_1 - \epsilon_2\right) \ln\left(d_2 + \bar{d_2}\right) \tag{30}$$

The luxury good parameter, $\bar{d_2}$ is set so that only the top 0.1% of the wealth distribution consume it. The relative preference for the non-energy good, ϵ_2, is identified using the share of emissions coming from the intermediate goods sector. This parameter determines the demand for the final good c, so the higher ϵ_2 is set, the greater the share of production emissions. I target this to match 70% of emissions arising from production, from Chancel and Rehm (2023). The subsistence level of the basic dirty good, $\bar{d_1}$, targets the bottom 50% share of emissions to be 17%, also from Chancel and Rehm (2023). As d_1 is a basic necessity good, the higher $\bar{d_1}$ becomes, the more consumption emissions can be attributed to the bottom 50% of wealth as they are forced to consume this minimum amount. While $\bar{d_1}$ governs absolute baseline energy needs, the relative preference for the basic dirty good, ϵ_1, is set to target the relative average energy expenditure share of the bottom 99% to that of the top 1%. This value is 1.6 from Starr et al. (2023a). In the numerator, the bottom 99% average energy expenditure share is solely determined by their consumption of d_1. The denominator contains two groups, one of which is wealthy but not rich enough to consume the luxury good d_2, while a small group of households can consume both d_1 and d_2. For the latter, ϵ_1 does not appear in their average energy expenditure share. This implies that ϵ_1 controls the relative energy usage across the wealth distribution. For example, increasing ϵ_1 results in the numerator rising more than the denominator, increasing the ratio of average energy expenditure shares across groups, since for the bottom 99% their energy shares rise disproportionately, whereas the impact on the top 1% average energy expenditure share is buffered by both their higher level of expenditures overall and preference for the luxury dirty good.

Entrepreneurial Productivity

For the entrepreneurship process, the standard deviation of entrepreneurial ability targets the top 0.1% share of wealth, which is taken from the literature to be 15.7% from Smith et al. (2022). A greater dispersion in ability between entrepreneurs means that a select few are able to amass greater profits, increasing wealth concentration.

Production Parameters

The energy share in the entrepreneur's technology, γ_e, targets the share of emissions by the top 0.1% which is 15.3% from Chancel and Rehm (2023). The reasoning for this is that for the top groups, the bulk of their emissions is arising from their entrepreneurial endeavours. The higher this γ_e, the larger is energy's share in their production technology, increasing the emissions footprint of wealthy entrepreneurs. Capital's share in the entrepreneur's technology is then simplified to be $\gamma_k = 1 - \gamma_e$, primarily to reduce computational complexity. For the energy firm, the term A_e governs their productivity and how much labour they require, so it is set to target the standard energy share of output of 4%. β is chosen to target the conventional capital-to-output ratio of 3, when $\delta = 0.05$.

4 Benchmark Model Performance

To assess the performance of the benchmark model, I do not target the top 1% and top 10% shares of wealth and assess how close they come to the data. The wealth distribution of the model matches the data closely, with the top 1% and top 10% wealth shares very close to their data counterparts.

Table 2: Shares of wealth by each group

	Wealth Distribution			
Group	Top 0.1%	Top 1%	Top 10%	Bottom 50%
Model	15.5%	35.9%	68.5%	3.3%
Data	15.7%	33.7%	68.6%	1.8%

Notes: For each wealth group, I compare the model's share of aggregate wealth for that group to the value in the data.

For the emissions distribution, I target the top 0.1% and bottom 50% share of U.S emissions and then assess how close the top 1%, top 10%, and middle 40% shares of emissions are to the data. The model overshoots the top 1% and 10% share of emissions by 6 percentage points and 8 percentage points respectively, while underestimating the middle 40% share of emissions. This is to be expected, given the absence of a mid-tier polluting consumption good, since this model only features basic or luxury dirty goods.

Table 3: Shares of emissions by each wealth group

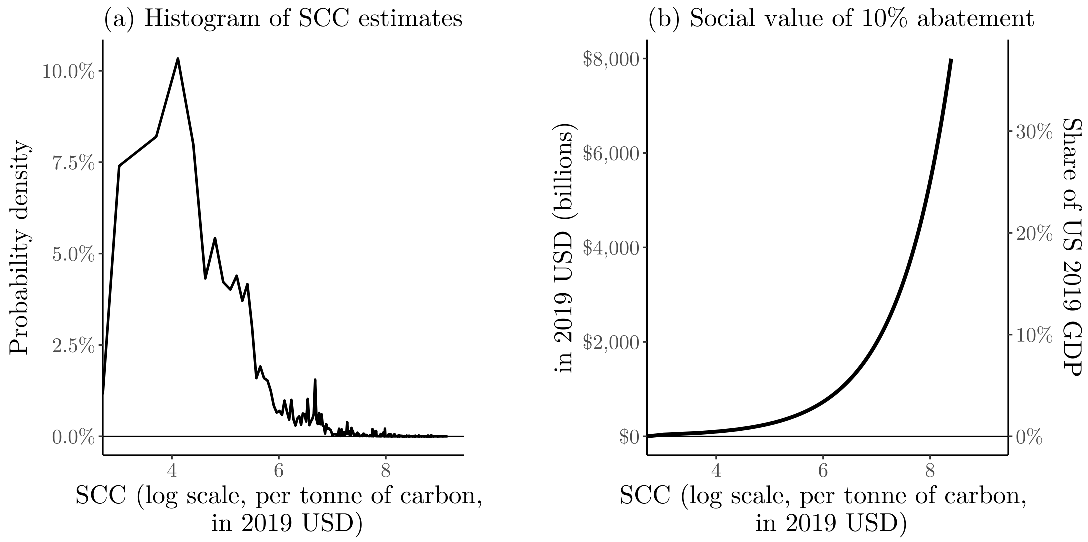
	Emission Distribution				
Group	Top 0.1%	Top 1%	Top 10%	Mid 40%	Bottom 50%
Model	15%	33%	59%	18%	17%
Data	15%	27%	51%	32%	17%

Notes: For each wealth group, I compare the model's share of U.S carbon emissions to the data. These values come from (Chancel and Rehm, 2023).

5 Comparative Analysis of Tax Instruments

In this section, I assess the impacts of achieving 10% emissions abatement using three different tax instruments on key outcomes: τ_s, the production emissions tax, τ_{d_1}, the basic-good tax, and τ_e, the uniform carbon tax. Extra revenue generated from the taxes, net of social security payments and the benchmark government spending, is then rebated to households in a lump-sum fashion. The social benefit of a 10% abatement is equal for all policies and estimated using the social cost of carbon (SCC). This includes the direct reduction in U.S. emissions and an indirect effect from the rest of the world abating in response to U.S. actions, assuming an elasticity of 0.3 (Barrage, 2023). I multiply this emissions reduction by a SCC of $120 USD (2020 dollars) per metric tonne of CO_2 using a discount rate of 2.5%, the most conservative estimate of the SCC provided by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency, 2023). It is then expressed relative to U.S. GDP to make it comparable to the economic welfare values. The wide range of estimates of the SCC found in the literature, shown in Figure 2, motivates my fixed-abatement approach. Figure 2(a) shows that, although most papers yield a SCC that is less than $1000, there is a long upper tail. Figure 2(b) maps these SCCs into the social value of abatement, assuming a rest-of-world emissions elasticity of 0.3, resulting in values that can reach more than $6 trillion USD and up to 30% of GDP.

Figure 2: Social value of 10% abatement

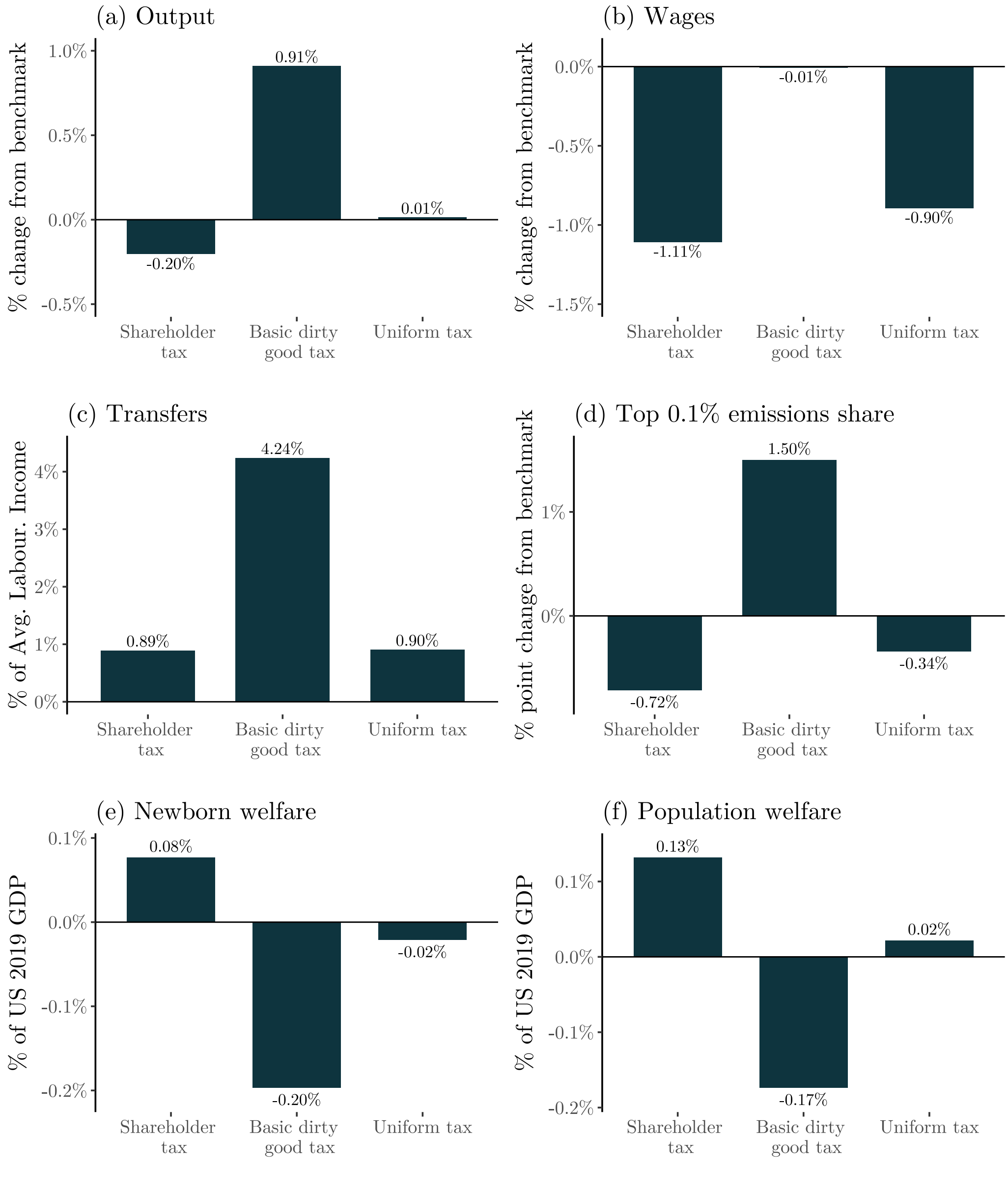


Notes: Panel (a) presents a histogram of social cost of carbon (SCC) estimates, constructed using data from Tol (2025), who compiles a database of SCC estimates from 443 papers. Panel (b) takes these estimates and evaluates the reduction in climate damages achieved by 10% abatement. The primary vertical axis represents this value in billions of 2019 USD, while the secondary vertical axis expresses this relative to the U.S. GDP in 2019.

Before discussing each policy, I present the main figures and tables that will serve as reference points for the analysis. Figure 3 and Figure 4 illustrate the aggregate and distributional outcomes across the three policies studied, allowing for direct comparison. The panels compare how output, inequality, transfers, wages, and welfare evolve across policies, with the shareholder tax shown in teal, the basic dirty good tax in orange, and the uniform tax in dark blue.

Figure 4(a) shows the distribution of welfare gains across the wealth distribution

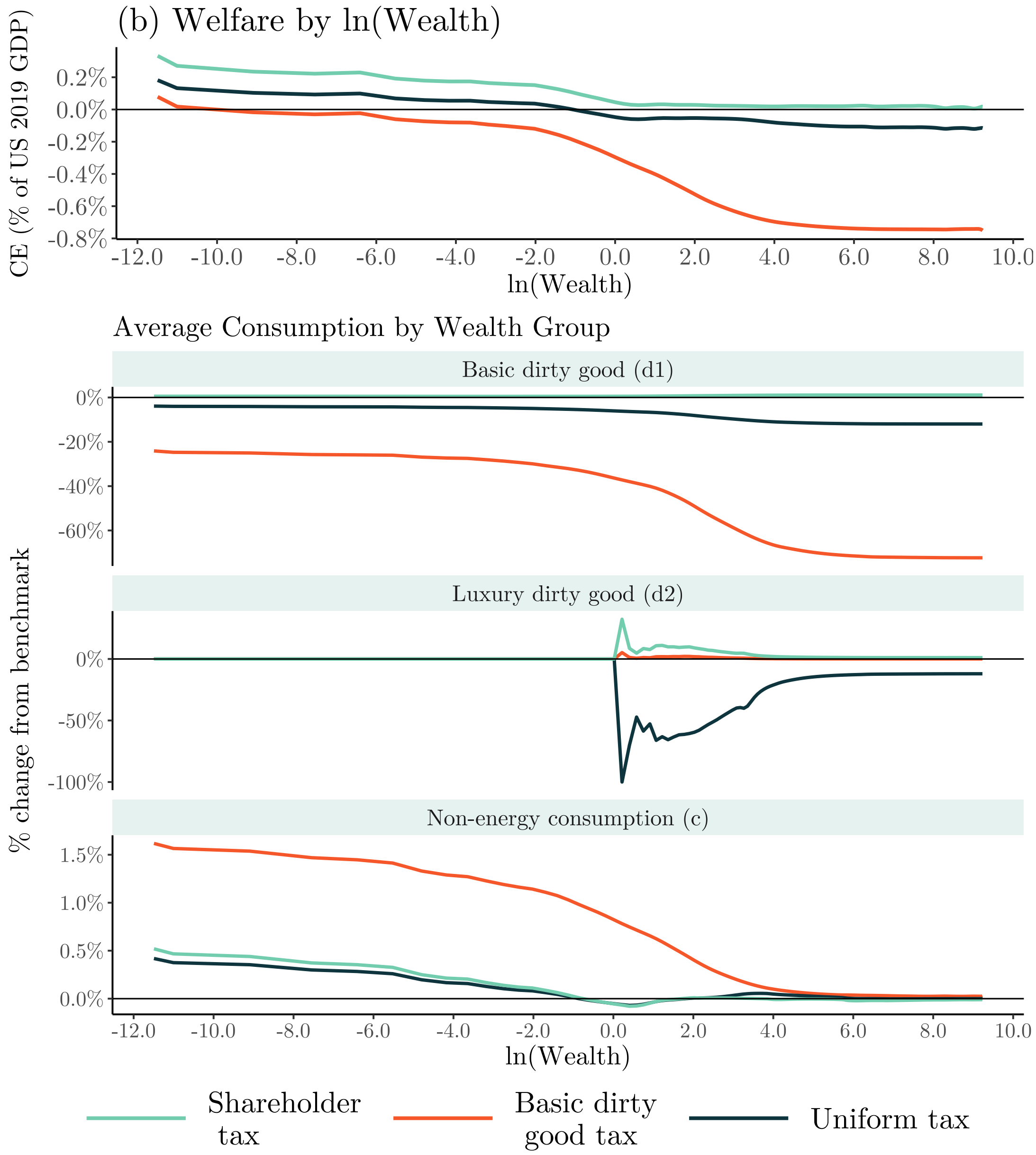
Figure 3: Results under 10% abatement



Notes: Panel (a) shows the percentage change relative to the benchmark steady state equilibrium in output (Y), Panel (b) the percentage change in wages w, Panel (c) the transfers as a share of average labour income, and Panel (d) the change in the share of emissions attributed to the top 0.1% of wealth, presented in percentage points. Panel (e) and (f) contain the welfare effects arising purely from the economic analysis, using consumption equivalents for both newborns (NB) and the entire population, scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. GDP in 2019. For each outcome, each bar illustrates the effects of abatement using one instrument at a time.

for each policy using the same colour scheme. Figure 4(b) illustrates where these gains are coming from by breaking down the change in consumption for each good by level of wealth.

Figure 4: Distributional Impacts Under 10% abatement



Notes: Panel (a) depicts the average consumption equivalents by level of wealth, scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. GDP in 2019. I take the natural log of wealth normalized by average wealth. Each line represents the three policies investigated. Panel (b) illustrates the percentage change, relative to the benchmark equilibrium, of average consumption of each of the three goods by wealth group under each of the three policies.

Table 4 contains the output decompositions for all the policies. The following equation decomposes the change in output arising from the labour reallocation channel, changes in TFP, and changes in raw inputs:

$$\log\left(\frac{Y'}{Y}\right) = \underbrace{(1-\alpha)\log\left(\frac{L'_y}{L_y}\right)}_{\text{Labour reallocation channel}} + \underbrace{\alpha\log\left(\frac{\int {k'_i}^{\gamma} {e'_i}^{1-\gamma}\,di}{\int k_i^{\gamma} e_i^{1-\gamma}\,di}\right)}_{\text{Raw inputs channel}} + \underbrace{\alpha\log\left(\frac{\mathrm{TFP_Q}'}{\mathrm{TFP_Q}}\right)}_{\text{TFP channel}} \tag{31}$$

where I define TFP in Q to be the ratio of quality-adjusted inputs and raw inputs into production:

$$TFP_Q = \frac{Q}{\int k_i^{\gamma} e_i^{1-\gamma} d_i} \tag{32}$$

The contributions of each channel are shown in Table 4 where each column represents each policy. Lastly, Table 5 captures how wealth inequality evolves across policies. The following sections now discuss each policy in turn.

Table 4: Decomposition of output change across policies

	Shareholder tax (τ_s)	Basic dirty good tax (τ_{d_1})	Uniform tax (τ_e)
Output change	-0.203%	0.907%	0.014%
Labour reallocation	0.603%	0.603%	0.603%
TFP channel	0.007%	0.008%	0.005%
Raw inputs channel	-0.813%	0.296%	-0.594%
Sum of channels	-0.203%	0.907%	0.014%

Notes: This table uses Equation 31 to decompose the channels contributing to the changes in output across all three policy experiments.

Table 5: Share of wealth change from benchmark equilibrium across policies

	Shareholder tax (τ_s)	Basic dirty good tax (τ_{d_1})	Uniform tax (τ_e)
Top 0.1%	0.048%	0.038%	0.079%
Top 1%	0.056%	0.078%	0.072%
Top 10%	0.049%	0.039%	0.044%

Notes: This table reports the percentage change from the benchmark steady state equilibrium to the abatement economy of the shares of wealth held by each wealth group under the three main policy experiments.

5.1 Production emissions tax results

I begin with the shareholder-facing tax that increases the price of energy used by entrepreneurs. Figure 3 immediately illustrates that, although this is the only policy under which output declines, it is also the only policy delivering welfare gains for both newborns and the population. The output decomposition exercise in Table 4 reveals that the decline in output (-0.2%) is largely due to a contraction of entrepreneurial activity. First, taxing entrepreneurial energy usage reduces their energy demand, decreasing the emissions arising from production. A decrease in equilibrium energy usage results in labour reallocating away from the energy sector to the final good sector, resulting in this channel having a positive impact (0.603%) on output, which is the same across all policies since abatement is held fixed. This channel is outweighed by the raw inputs channel (-0.8%). Since entrepreneurs reduce their energy demand in response to the tax, they consequently demand less capital since reduced energy usage also lowers capital productivity, thus contracting entrepreneurial activity, bringing output down with it

The third channel captures how changes in TFP impact output. Misallocation improves under this policy because of differential responses from constrained and unconstrained entrepreneurs. When taxes such as τ_s (and later τ_e) raise energy prices, entrepreneurs scale back their energy usage, shifting down the marginal returns from operating one more unit of capital. For some constrained firms, who also tend to be more productive, this new optimal level of capital is still above their constraint and so their capital-use remains unchanged. For constrained firms with relatively higher wealth, they now find themselves able to operate at the new lower optimal level of capital, so in equilibrium there are fewer constrained firms than before. Lastly, for the unconstrained groups, they reduce their capital usage uniformly. Since the bulk of capital reduction is done by unconstrained entrepreneurs, who are generally less productive, while the capital usage of the most productive entrepreneurs remains unchanged, misallocation improves under τ_s and τ_e. Capital becomes more concentrated at the top, with wealth inequality rising for the top 0.1%, 1%, and 10% as shown below in Table 5.

This differential response between constrained and unconstrained entrepreneurs is also responsible for the decline in carbon inequality (-0.72 percentage points) shown in Figure 3(d). For unconstrained firms, energy efficiency is pinned down by the following equation:

$$\frac{e_h}{k_h} = \frac{1-\gamma_k}{\gamma_k} \cdot \frac{(r+\delta)}{p_e\,(1+\tau_s)}. \tag{33}$$

τ_s increases the price of energy relative to capital, so production becomes more capital-intensive as unconstrained entrepreneurs substitute away from energy. This effect is uniform and independent of an entrepreneur's ability. For constrained firms, how their energy-to-capital ratio responds depends on their productivity and the extent of their leveraging:

$$\frac{e_h}{k_h} = \left[\frac{\mathcal{R}\,\mu\,(1-\gamma_k)\,z^{\mu}}{p_e\,(1+\tau_s)\,\left(\vartheta(\bar{z})\,a\right)^{1-\mu}} \right]^{\frac{1}{1-\mu(1-\gamma_k)}}. \tag{34}$$

While τ_s will reduce their energy intensity, keeping all else fixed, this interacts with the constrained entrepreneur's productivity and wealth. Wealthier constrained firms can leverage more and operate closer to their optimal capital demand, so they need relatively less energy per unit of capital. In contrast, highly productive but wealth-poor constrained entrepreneurs are far from their desired optimal capital level, so they substitute with more energy, pushing up their $\frac{e}{k}$ ratios. When a tax on production emissions is implemented, the constrained firms cannot adjust capital usage flexibly, so they cut back more sharply on energy, resulting in a more drastic reduction in their energy-to-capital use. The more capital-constrained a firm is, the more sensitive their energy-to-capital use to policy changes. As these constrained (and typically more productive) entrepreneurs are reducing their energy usage more aggressively relative to other groups, this heterogeneous response curbs carbon inequality at the top. The ability of a production emissions tax to disproportionately target emissions at the top suggests the importance of a carbon tax that is not only consumer-facing but also producer-facing. In the absence of an implementable carbon tax, a shareholder tax operates in the same way and can reduce carbon inequality while also reducing emissions.

Turning to welfare, the shareholder tax delivers the largest gains of all the policies considered. Although reduced economic activity depresses wages (-1.11%) and the rise in transfers (0.89%) cannot offset it, welfare is increasing for both newborns (0.08%) and the population (0.13%). Figure 4 illustrates where these gains come from. For the lowest wealth groups, their consumption of the non-energy good rises slightly (approximately 0.5% for the lowest wealth group). This is in large part due to the lump-sum transfers raised from the shareholder tax. For all other wealth groups, they experience a slight rise in their consumption of the basic dirty good, the substitute for the non-energy consumption good. For the richest groups, the bulk of their welfare gains come from the change in their consumption of the luxury dirty good. As the relative price of the luxury dirty good to the non-energy good falls, they shift their consumption basket to consuming more of it. Taken together, while this tax contracts output and wages, both low-wealth and rich households like it for different reasons. This distinguishes it from the other policies, which either reduce welfare or benefit some groups while hurting others.

5.2 Basic dirty good carbon tax results

In contrast, achieving 10% abatement using solely a basic dirty good tax has the opposite effects on both aggregate and welfare outcomes. Figure 3 contains the results of abating using a consumption emissions tax alone. To begin with, this is the only policy under which output rises (0.91%). The output decomposition exercise in Table 4 reveals that the contribution of the labour reallocation channel (0.603%) is no longer reversed by the raw inputs channel (0.296%), with a negligible effect from the TFP channel (0.008%). Entrepreneurial activity expands with this policy for two reasons. Increasing the price of the basic dirty good using τ_{d_1} alters a household's consumption-savings behaviour. First, the relative price of the non-energy good c to d_1 falls, so households shift their consumption basket to consume more of c, increasing their demand for the good produced by entrepreneurs. Second, due to the decreased incentive to consume c, households save more, which relaxes the collateral constraints of constrained entrepreneurs. Entrepreneurs respond to both the increased demand for their good and relaxed collateral constraints by raising capital and energy demand, thus raising output.

The TFP channel, while small, also boosts output. A consumption tax on the basic dirty good improves misallocation slightly more than a production emissions tax, although for different reasons. On one hand, reduced demand for the basic dirty good shifts people to the substitute. Increased demand for the final good c results in unconstrained firms increasing their use of capital. At the same time, with the reduced incentive to consume, households accumulate more wealth, which relaxes the collateral constraints of the constrained entrepreneurs. The tension then is whether the collateral constraint can rise faster than the new desired optimal level of capital. For the most productive constrained firms, the loosening of the constraints dominates, and we see shares of wealth held by the top 1% and 10% rise as shown in Table 5. Since capital is now more concentrated in the hands of the most productive, wealth inequality rises across the key groups. The same cannot be said for carbon inequality.

This output gain comes at the cost of increased carbon inequality, shown in Figure 3(d). The share of emissions attributed to the wealthiest 0.1% rises by 1.5 percentage points. While the price of energy remains relatively unchanged under this policy, the cost of capital r rises due to the increased capital demand from entrepreneurs. For constrained firms, their collateral constraint limits their production abilities and r does not appear in Equation (34). With no change in prices, these firms experience a rise in the marginal productivity of their energy inputs through higher demand for their goods, through a rise in $\mathcal{R}$, resulting in greater energy usage as well. Since both groups experience a rise in their energy-to-capital ratios, the relative energy usage of all entrepreneurs rises, and as there are more entrepreneurs in top wealth groups relative to the rest of the population, the shares of emissions at the top rise from their production carbon footprints expanding.

Wages do fall slightly under this policy (-0.0073%), because although entrepreneurial activity expands, putting upward pressure on wages, this is not enough to counteract the downward pressure on wages exerted by labour reallocating away from the energy sector to the final good sector. Although transfers rise the most under this policy (4.23% of average labour income), this is a gain that only seems to benefit the least wealthy, as seen in Figure 4(a). Both newborn and population welfare fall (-0.197% and -0.174%) because while the lowest wealth households gain from the slight increase in their consumption of c (1.6%), all other groups suffer from heavily reducing their consumption of the necessity good. This policy induces the heaviest substitution towards the non-energy good c, shown in Figure 4(b), and while rich households do still substitute towards the luxury dirty good, it is not as strong of an effect as with the shareholder-facing tax. Importantly, the substitution towards the other goods is not enough to make up for the steep decline in their consumption of the necessity dirty good, leading to welfare losses across most of the wealth distribution.

5.3 Uniform carbon tax results

The uniform carbon tax raises the price of consumption and production emissions by the same amount and balances the outcomes discussed in the previous policies. First, output rises very slightly by 0.014%. The labour reallocation channel plays a strong positive role (0.603%) which the decline in the raw inputs channel cannot negate (-0.594%). Although entrepreneurial activity declines, it does not contract as much as under τ_s. This is largely because the reduced incentive to consume across all goods relaxes collateral constraints, as discussed in the previous section. However, output rises by less under this policy compared to the basic dirty good tax since taxing production emissions means that entrepreneurial activity cannot rise as freely as it did under the basic dirty good tax. The TFP channel also plays a small but positive role (0.005%), albeit the least of all the other policies, improving for the reasons discussed in the shareholder carbon tax section. Similarly, we see top wealth shares rise, shown in Table 5.

The share of emissions attributed to the top 0.1% of wealth falls by 2%, only half of the decline we see under τ_s, as the richest consume less of the luxury dirty good, shown in Figure 4(b), and shrink their production emissions footprint due to the cost of their energy inputs rising. Since the price of energy rises more relative to the cost of capital under this tax, entrepreneurs use relatively less energy to capital, shrinking their carbon footprints, which shows up as less emissions attributed to the wealthiest.

The labour reallocation channel is largely responsible for the -0.9% decline in wages, and although transfers amount to 0.9% of average labour income, average newborn welfare declines slightly (-0.021%) while average population welfare rises (0.0217%), illustrated in Figure 3(e) and (f). All wealth groups reduce their basic dirty good consumption, but the lowest wealth groups use the transfers to slightly increase their consumption of the non-energy good c (up by at most 0.5%). Wealthy individuals cut their average consumption of the basic dirty good more than their less wealthy counterparts. Due to the necessary nature of this good for lower-wealth households, there is a limit to how much they can cut their consumption of this necessity. Higher wealth households are consuming far beyond what is necessary, making their cuts steeper in response to the tax. Wealthy individuals also drastically reduce their consumption of the dirty luxury good since they can no longer substitute away to an untaxed good. Figure 4(a) contains average welfare over the wealth distribution, showing that it is largely low-wealth households benefiting from this policy, with welfare losses for moderately wealthy to high-wealth households. Most notably, every wealth group experiences lower average welfare under this policy compared to the shareholder tax.

5.4 Eliminating the luxury dirty good

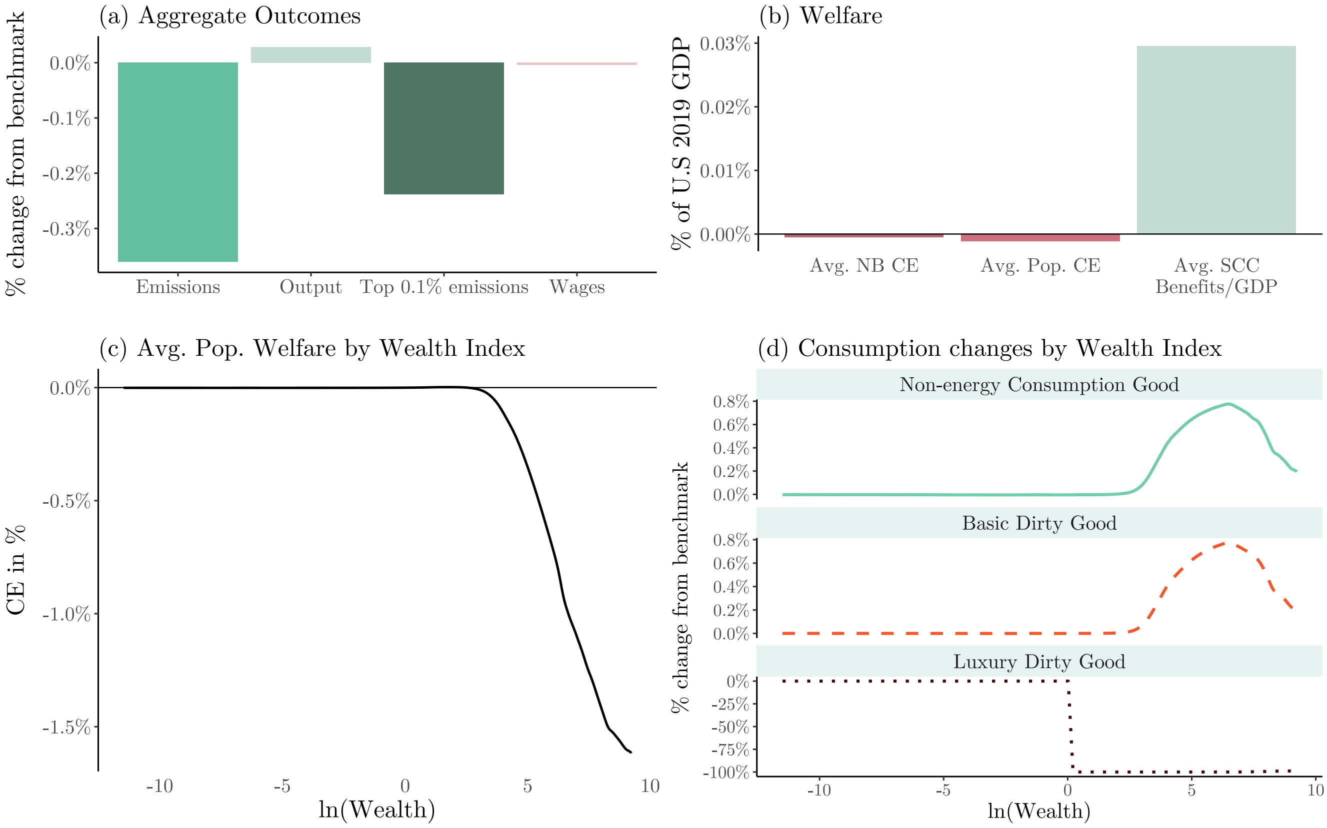
Although luxury goods account for a small share of emissions, they have been the subject of much media attention. I run an experiment in which the tax on the luxury good is set sufficiently high to eliminate its use completely. The results are shown in Figure 5. The net effect on emissions, in Figure 5(a) is a decline of 0.36%, the social value of this decline being around 0.03% of U.S. 2019 GDP (Figure 5 (b)). Even though these rich households do substitute away towards the basic dirty good d_1, as shown in Figure 5(d), the net effect on emissions is still negative. Output rises by a meagre 0.03%, largely because of the labour reallocation channel, as shown in Table 6. Entrepreneurial activity does slightly expand because rich households are also substituting towards c as well, the good made by the entrepreneurs, resulting in quality-adjusted entrepreneurial activity Q (not depicted) rising by 0.0201%. The share of emissions attributed to the wealthiest 0.1% declines by roughly 1.5%, making it more effective at curbing inequality than the basic dirty good tax, but less effective compared to the shareholder tax and uniform carbon tax.

Table 6: Decomposition of output change into channels

Channel	**Contribution**
Output change	0.029%
Labour reallocation channel	0.022%
TFP channel	−0.002%
Raw inputs channel	0.009%
Sum of channels	0.029%

Notes: This table uses Equation 31 to decompose the channels contributing to the changes in output.

Figure 5: Results from eliminating the luxury good



Notes: Panel (a) shows the percentage change relative to the benchmark steady state equilibrium in emissions, output (Y), the share of emissions attributed to the top 0.1% of wealth, and wages w. Panel (b) first shows the welfare effects arising purely from the economic analysis, using consumption equivalents for both newborns (NB) and the entire population, scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. GDP in 2019. The changes in welfare arising from changes in levels and distributions are also depicted. The monetary value of emissions reduction is shown in the last bar. Panel (c) depicts the average consumption equivalents for each wealth level, where the natural log is taken over the value of wealth normalized by average wealth, scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. GDP in 2019. Panel (d) illustrates the percentage change, relative to the benchmark equilibrium, of average consumption of each of the three goods by wealth.

Wages decline by 0.0044%, a very small amount as labour is reallocating from the energy sector to the final good sector. Welfare in Figure 5(c) does decline by a small amount for low wealth households (-0.002%), which is not very visible on the graph. The noticeable declines in welfare occur for the richest groups, who see their consumption of the luxury good decline by 100%. Although they do substitute towards the other two goods, shown in Figure 5(d), this is not enough to compensate. Thus, average newborn and population consumption equivalents, shown in Figure 5(b) both decline, although by very small amounts, -0.0005% and -0.0012% respectively.

Table 7: Share of wealth change from benchmark equilibrium

	Top 0.1%	Top 1%	Top 10%
Wealth Change	-0.050%	-0.031%	-0.004%

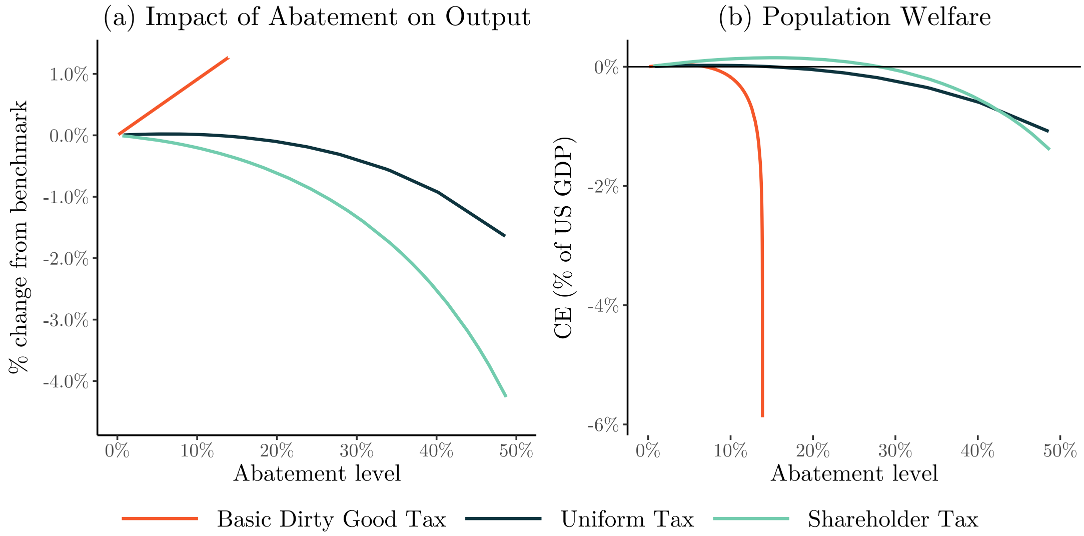
Notes: This table reports the percentage change from the benchmark steady state equilibrium to the abatement economy of the shares of wealth held by each wealth group in the top row.

6 Robustness

In this section, I assess the robustness of my general conclusions to the level of abatement the policymaker chooses. Figure 6 contains output changes and population welfare under varying abatement levels (newborn welfare is omitted as it looks similar). Figure 7 illustrates the distributional effects arising from implementing different abatement levels with each of the policies. First, since it taxes a necessity good, there is a limit to how much abatement can be achieved with the basic dirty good tax alone, which is around 15%. The welfare losses of this policy are very steep relative to abating the same amount with the other instruments, as taxing the necessity good is painful. While for low levels of abatement, low-wealth households benefit from this transfer, even these groups eventually experience painful welfare losses if the basic dirty good tax alone is used to achieve high levels of abatement. Overall, the general story that this tax increases output, but at the cost of welfare still holds for all the levels of abatement possible using this instrument alone.

Second, the shareholder tax reduces output but the result that it delivers positive welfare holds only up to a certain level of abatement, as can be seen in Figure 6(b). Newborn welfare turns negative at around 21% abatement, while population welfare turns negative when abating more than 28% using this policy alone. Figure 7(a) shows that for moderate levels of abatement, both low-wealth and rich households benefit, while welfare begins to deteriorate for middle-wealth groups with higher abatement levels, due to lower wages and contracted entrepreneurial activity. These groups cannot consume d_2 but also do not benefit as much from the transfer as the lower-wealth groups. This deterioration

Figure 6: Output and Welfare under Different Abatement Levels



Notes: Panel (a) illustrates the percentage change in output from the benchmark steady state to alternative steady states with varying levels of abatement. Each line represents achieving that abatement using only one policy alone. Panel (b) displays the welfare impacts of different levels of abatement. These are welfare effects arising purely from the economic analysis, using consumption equivalents for the entire population, scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. GDP in 2019. Each line represents the welfare outcome when only one instrument is applied at a time.

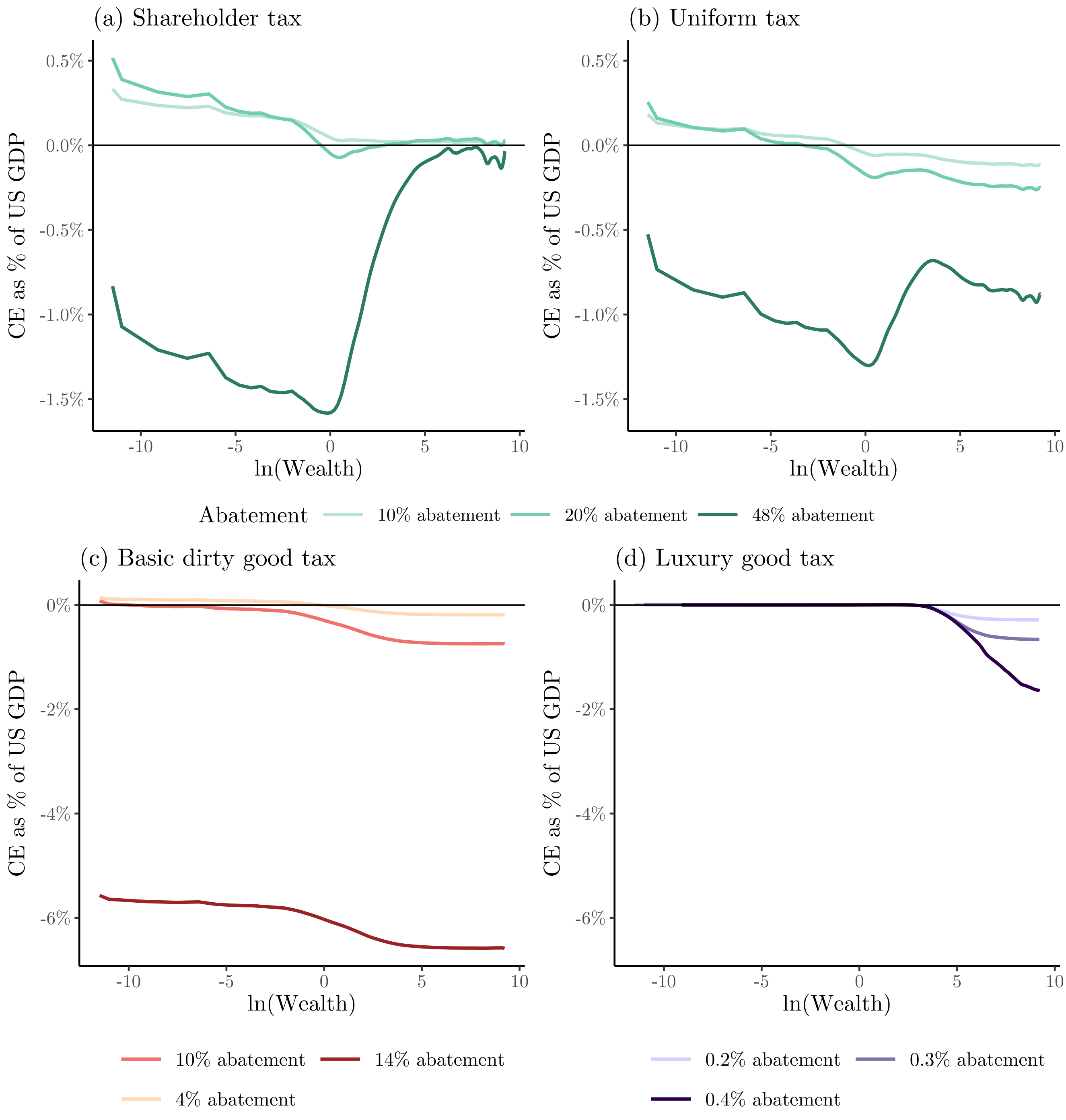
becomes larger the more we abate using solely a shareholder-facing tax, eventually even resulting in welfare losses for all groups. However, it still remains better for welfare than using a uniform carbon tax until we reach an abatement level of approximately 40%. After this point, abating using the uniform tax delivers higher average population welfare relative to using any one instrument alone. However, this comes with the caveat that the richest groups would still prefer the shareholder tax even at high levels of abatement, as can be seen in Figure 7. These groups have a higher average welfare because they can easily substitute to d_2, unlike with a uniform carbon tax. While it is clear there is some substitution still happening under τ_e, it is not as much.

Lastly, varying the luxury good tax increasingly hurts the wealthiest households disproportionately. However, for smaller levels of abatement, it can generate small revenues that, when rebated back to households, can very slightly increase welfare for the lowest-wealth households.

7 Optimal Policy

The optimal policy is the set of taxes that maximize the average value of newborns to achieve the emissions reduction target set by the U.S. for 2030 of a 50% reduction from 2005 emission levels. According to data from the EPA, there is approximately 34%

Figure 7: Welfare by Policy under Different Abatement Levels



Notes: Each panel shows the average welfare by wealth, which is the natural log taken over the value of wealth normalized by average wealth, expressed in consumption equivalents (CE) scaled by U.S. Private Final Consumption Expenditure in 2019, relative to U.S. 2019 GDP, for different levels of abatement when only one tax instrument is applied. Panel (a) reports outcomes under the shareholder tax and Panel (b) under the uniform carbon tax, with both achieving the same levels of abatement (10%, 20%, and 48%). Panel (c) shows the basic dirty good tax, which can only achieve up to 14% abatement, while Panel (d) shows average welfare by wealth group when varying the levels of abatement from 0.2% to 0.4% using the luxury dirty good tax.

emissions reduction remaining to be made (U.S. Environmental Protection Agency, 2024). More formally, the planner chooses tax instruments $\{\tau_{d_1}, \tau_{d_2}, \tau_s\}$ to maximize the average welfare of newborns, subject to achieving a target level of emissions abatement $\bar{A}$ relative to the benchmark economy. Formally:

$$\max_{\tau_{d_1},\tau_{d_2},\tau_s} \quad \frac{\sum_{\mathbf{S}} V_1(\mathbf{S})\Gamma_1(\mathbf{S})}{\sum_{\mathbf{S}} \Gamma_1(\mathbf{S})} \tag{35}$$

$$\text{s.t.} \quad -\frac{e(\tau_{d_1}, \tau_{d_2}, \tau_s) - e^B}{e^B} = \bar{A} \tag{36}$$

where $e(\tau_{d_1}, \tau_{d_2}, \tau_s)$ denotes aggregate emissions under the tax vector $(\tau_{d_1}, \tau_{d_2}, \tau_s)$, and e^B is the benchmark emissions.

A 34% emissions reduction can be achieved in two ways: using a uniform carbon tax of 42.5% or using the optimal policy, which is a basic dirty good tax of 97%, shareholder tax of 69.5%, and luxury good tax of 160%. Despite achieving the same reduction, the welfare and economic outcomes are different. First, average welfare of the newborns entering the economy drops by 0.2% with the optimal policy as opposed to around 1% under the uniform tax. Average population welfare increases by 0.12%, while dropping by 0.7% under the uniform tax. While some of this welfare change does arise because of redistribution, the negative impact the change in levels has on population welfare is smaller under the optimal tax (-0.02% rather than -0.03%).

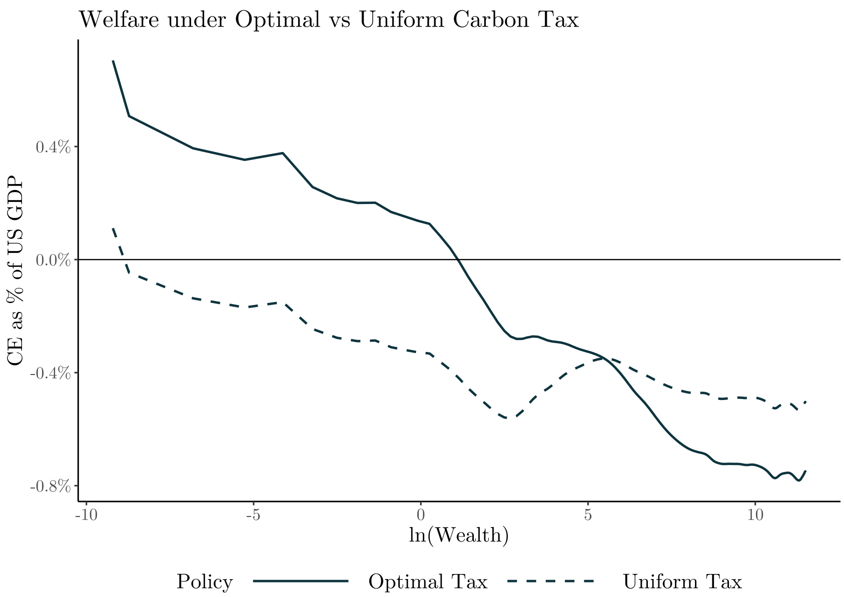
Table 8: Comparison of Outcomes under τ_e and Optimal Policy

	τ_e	Optimal Policy
Emissions Reduction	34.00%	34.00%
Newborn CE	-0.99%	-0.21%
Population CE	-0.69%	0.12%
CE_{level}	-0.03%	-0.02%
$\text{CE}_{\text{distribution}}$	0.60%	0.75%
Output change	-0.57%	-0.39%
Raw inputs channel	-2.61%	-2.44%
TFP channel	0.015%	0.022%
Labour channel	2.03%	2.03%
Top 0.1% Emissions Share	-1.63*pp*	-1.45*pp*
Wages	-3.57%	-3.40%
Q change	-7.35%	-6.85%
Transfer (LS/ALI)	3.27%	4.16%

Notes: This table compares the percentage change from the benchmark equilibrium to the uniform carbon tax or optimal policy equilibrium that would arise for each outcome reported.

The reason for the improved outcomes under the optimal tax is that a mixture of taxes that target consumption and production emissions differently allows a relatively larger chunk of emissions reduction to come from the reduction of consumption emissions from both d_1 and d_2 rather than cuts in production emissions. Since consumption emissions taxes are larger than the shareholder emissions taxes, they buffer the impact on output and wages as households cut back on their consumption of dirty goods, demand more of the non-energy consumption good while at the same time saving more. Since emissions used in production are taxed relatively lower, entrepreneurs can adjust their activities accordingly and expand production, particularly the entrepreneurs who see their collateral constraints relax. Subsequently, the raw inputs channel declines by less (-2.44%) than in the case with a uniform carbon tax (-2.61%). Additionally, the contribution of the TFP channel is also slightly greater with the optimal tax, at 0.022% versus the 0.015% under the uniform tax. This also shows up in quality-adjusted energy-capital composite Q falling by less under this optimal policy (-6.85% versus -7.35%). This stronger effect is made possible because of the higher tax on the basic dirty good. I showed in Section 5.2 that a basic dirty good tax leads to the highest TFP gains, as the loosening of collateral constraints primarily benefits constrained but productive entrepreneurs. However, as entrepreneurial activity contracts less under the optimal policy, both in terms of their raw inputs and quality-adjusted activity, this also means that it reduces carbon inequality by less, at a -9.6% reduction compared to -10.7% under the uniform tax.

Figure 8: Welfare by Wealth Group Comparison



Notes: This figure illustrates how average newborn welfare for each wealth index varies under the optimal tax (red and solid line) as opposed to the uniform tax (blue and dashed).

To better understand the distributional impacts of using the optimal tax over a uniform tax, Figure 8 illustrates the average population welfare by wealth group across both policies. The optimal tax delivers higher and sometimes positive average welfare for the wealth groups that comprise the majority of the population. This is occurring due to both wages declining by less under the optimal policy and also because the optimal tax generates higher tax revenue, so households benefit from the lump-sum transfer. However, this pattern starts to reverse for wealthier households who prefer the uniform tax. This is largely because the optimal policy taxes the luxury dirty good that these wealthy households consume almost four times higher than the tax they would see under the uniform policy. Overall, while the wealthiest do not like this policy as much, it delivers higher welfare for both newborns and the general population compared to the uniform policy.

8 Conclusion

With growing evidence documenting carbon inequality, policymakers are increasingly exploring alternatives to a uniform carbon tax that take a more targeted approach to reducing emissions, such as a shareholder-facing carbon tax or a tax on consumption emissions, particularly of the very rich. Rather than investigating the level of abatement that should occur, this paper takes the level of abatement as given in the first set of experiments and then uses one policy at a time to achieve that reduction. The policies evaluated are a tax on production emissions, a tax on consumption emissions arising from the consumption of a basic dirty good, and lastly, a uniform carbon tax equally impacting both consumption and production emissions. I then investigate the aggregate and distributional impacts of using the more targeted taxes and evaluate their impacts relative to a uniform carbon tax, in a setting featuring extreme wealth concentration via rate of return heterogeneity.

I find that producer-facing taxes, such as the shareholder carbon tax, lower carbon inequality through differential impacts on constrained and unconstrained entrepreneurs, and also improve the efficient allocation of resources. Although output and wages fall, all wealth groups experience welfare gains. This is because the absence of a consumption emissions tax induces households to substitute from the non-energy good towards consuming more of the basic and luxury dirty goods, over which they have non-homothetic preferences. In contrast, consumer-facing carbon taxes induce households to substitute away from the dirty goods, increase demand for the non-energy good, and accumulate more savings. These have the combined effect of raising output and buffering the decline in wages, but since entrepreneurial activity expands, we see a worsening of carbon inequality as wealthier entrepreneurs expand their production emissions footprint. Overall, welfare declines as this tax targets the basic necessity good. Lastly, a uniform tax balances these trade-offs as it targets consumption and production emissions equally. While entrepreneurial activity does decline, it does so by less than using a production emissions tax alone because of the channels that operate when consumption emissions are taxed. However, newborn welfare declines due to sharp declines in the basic and luxury dirty good. Average population welfare experiences a slight gain as transfers buffer some welfare impacts at the low end of the wealth distribution and households consume slightly more of the non-energy good. However, this welfare gain is smaller than what the production emissions tax achieves.

In the second experiment, I investigate the impacts of eliminating the luxury good entirely. Emissions decline by 0.36%, the social value of which reaches 0.03% of U.S. 2019 GDP using a conservative estimate for the SCC. Output rises 0.03% as the rich substitute towards the non-energy good and entrepreneurs slightly expand their activity. Nevertheless, both newborns and the population experience a welfare loss on average, driven entirely by the welfare loss of high-wealth households. However, the social value of abating the emissions from luxury good consumption is still larger than these welfare losses.

Overall, the first set of experiments reveals that no single instrument dominates the others when evaluated across output, wages, welfare, carbon inequality, and welfare impacts along the wealth distribution at moderate levels of abatement. The robustness checks assess how well these results hold up at different abatement targets. First, the basic dirty good tax can only abate up to a maximum of 15% but with heavy welfare losses reaching up to 4% of U.S. GDP. The shareholder tax results in welfare gains for moderate levels of abatement. Although it yields welfare losses after roughly 21% and 28% abatement for newborns and the overall population respectively, it still outperforms the uniform carbon tax. However, this reverses at 40% abatement, after which the uniform tax is better than relying solely on taxing production emissions.

Lastly, I explore the optimal policy structure required to meet the U.S. pledge of reducing emissions by 50% of 2005 levels by 2030. To achieve the remaining 34% abatement, I use a uniform tax and an optimal policy that uses a high tax on luxury consumption emissions, moderately high tax on basic dirty good consumption, and relatively lower tax on production emissions. This differential taxation structure results in higher welfare outcomes for both newborns and the overall population due to two mechanisms. First, the higher consumption emissions taxes encourage households to switch from the dirty goods to the non-energy good produced by entrepreneurs and also accumulate more savings. Second, the lower production emissions taxes allow entrepreneurs to expand their activity to meet their demand while constrained entrepreneurs experience loosening collateral constraints as their savings rise. These channels buffer the decline in output we would otherwise see with the uniform carbon tax.

Overall, by featuring heterogeneity in both production and consumption emissions, this framework provides a comprehensive analysis of how targeted carbon taxes can improve welfare, productivity, and aggregate economic outcomes relative to a uniform carbon tax at moderate levels of abatement. The results reveal that how abatement occurs is as relevant for welfare as the amount of abatement that should occur. These findings underscore the importance of developing nuanced climate policies that consider the broader economic and social impacts of emissions reduction strategies.

References

Barrage, L. (2023). Fiscal costs of climate change in the united states. Technical Report 23/380, ETH Zurich, CER-ETH - Center of Economic Research, Zurich.

Belfiori, M. E., Carroll, D., and Hur, S. (2024). Unequal climate policy in an unequal world. *Globalization Institute Working Paper*, (427).

Bell, F. C. and Miller, M. L. (2005). *Life tables for the United States social security area, 1900-2100*. Number 120. Social Security Administration, Office of the Chief Actuary.

Caggese, A., Chiavari, A., Goraya, S., and Villegas-Sanchez, C. (2024). Dp19164 climate change, firms, and aggregate productivity. Technical report, CEPR Discussion Paper No. 19164. CEPR Press, Paris & London.

Chancel, L. (2022). Global carbon inequality over 1990–2019. *Nature Sustainability*, 5(11):931–938.

Chancel, L. and Rehm, Y. (2023). The carbon footprint of capital: Evidence from france, germany and the us based on distributional environmental accounts.

Douenne, T. and Fabre, A. (2020). French attitudes on climate change, carbon taxation and other climate policies. *Ecological Economics*, 169:106496.

Douenne, T., Hummel, A. J., and Pedroni, M. (2023). Optimal fiscal policy in a climate-economy model with heterogeneous households. *SSRN*. Available at SSRN: https://ssrn.com/abstract=4018468 or http://dx.doi.org/10.2139/ssrn.4018468.

Golosov, M., Hassler, J., Krusell, P., and Tsyvinski, A. (2014). Optimal taxes on fossil fuel in general equilibrium. *Econometrica*, 82(1):41–88.

Guvenen, F., Kambourov, G., Kuruscu, B., Ocampo, S., and Chen, D. (2023). Use It or Lose It: Efficiency and Redistributional Effects of Wealth Taxation*. *The Quarterly Journal of Economics*, 138(2):835–894.

Kim, S. (2023). Optimal carbon taxes and misallocation across heterogeneous firms. *Available at SSRN 4844030*.

Li, H. (2022). Leverage and productivity. *Journal of Development Economics*, 154:102752.

Lian, C. and Ma, Y. (2020). Anatomy of corporate borrowing constraints*. *The Quarterly Journal of Economics*, 136(1):229–291.

Lyubich, E., Shapiro, J., and Walker, R. (2018). Regulating mismeasured pollution: Implications of firm heterogeneity for environmental policy. *AEA Papers and Proceedings*, 108:136–142.

Maitland, A., Lawson, M., Stroot, H., Poidatz, A., Khalfan, A., and Dabi, N. (2022). Carbon billionaires: The investment emissions of the world's richest people. Retrieved from https://southasiacommons.net/artifacts/4520527/carbon-billionaires/5335575/ on 08 May 2024. CID: 10.21201/2022.9684.

McDaniel, C. (2007). Average tax rates on consumption, investment, labor and capital in the oecd 1950-2003. *Manuscript, Arizona State University*, 19602004.

Nordhaus, W. D. and Boyer, J. (2003). *Warming the world: economic models of global warming*. MIT press.

Rotberg, S. and Steinberg, J. B. (2024). Tax evasion and capital taxation. *Journal of Political Economy*, 132(7):2488–2529.

Smith, M., Zidar, O., and Zwick, E. (2022). Top Wealth in America: New Estimates Under Heterogeneous Returns*. *The Quarterly Journal of Economics*, 138(1):515–573.

Starr, J., Nicolson, C., Ash, M., Markowitz, E. M., and Moran, D. (2023a). Assessing u.s. consumers' carbon footprints reveals outsized impact of the top 1*Ecological Economics*, 205:107698.

Starr, J., Nicolson, C., Ash, M., Markowitz, E. M., and Moran, D. (2023b). Income-based u.s. household carbon footprints (1990–2019) offer new insights on emissions inequality and climate finance. *PLOS Clim*, 2(8):e0000190.

Tol, R. S. J. (2025). Database for the meta-analysis of the social cost of carbon (v2025.1).

U.S. Environmental Protection Agency (2023). Report on the social cost of greenhouse gases: Estimates incorporating recent scientific advances. Technical report, National Center for Environmental Economics, Office of Policy, Climate Change Division, Office of Air and Radiation, Washington, DC 20460. Docket ID No. EPA-HQ-OAR-2021-0317. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review".

U.S. Environmental Protection Agency (2024). Data highlights: Inventory of u.s. greenhouse gas emissions and sinks 1990-2022. Technical report, U.S. Environmental Protection Agency, Office of Air and Radiation, Climate Change Division, Washington, DC.